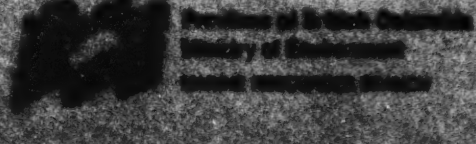
A REPORT
ON THE DEVELOPMENT AND USE OF AN ARTIFICIAL CULTCH SUITABLE FOR OFF BOTTOM OYSTER CULTURE IN BRITISH COLUMBIA

by

C. Robert Gunn



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All opinions expressed in this report are solely those of the author and do not necessarily reflect the view of the Marine Resources Branch.

ABSTRACT

In 1981, a search was undertaken for a suitable material to substitute for the traditional shell cultch used in both near and off bottom culture of Pacific oysters. Various materials were tested and a polyvinylchloride 2 m tube with an outside diameter of 20 mm was chosen. Subsequent work in 1982 and 1983 concentrated on handling and harvesting methods, in addition to achieving spat settlement on the tubes in setting tanks using hatchery-produced eyed larvae. Results were promising and use of the tubes has been found to improve the economics of longline oyster culture in British Columbia.

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BACKGROUND

Cultch is the name given to material used as a substrate for attachment of oyster larvae. Shell piles from oyster shucking houses have traditionally provided most of the cultch for the British Columbia oyster industry. While oyster shell cultch is suitable for bottom culture, its limitations are becoming more apparent to oyster growers in this Province as they begin to adopt new techniques of growing oysters. Techniques such as stake culture (Clayton and Pobran, 1981) and hanging or off bottom culture (either longline or raft culture) have great potential for British Columbia. Stake culture allows use of soft or muddy ground, and deep water can be utilized with hanging culture. In these ways, the area available for oyster growing in British Columbia is being expanded. In addition, these culture techniques reduce growing times (Quayle, 1969).

During the late 1970's, a group of growers began using off bottom culture techniques in British Columbia. One group, a Native Indian operation, was monitored closely by the Marine Resources Branch (Clayton and Smith, 1980). The growers' early work used a modification of the twisted wire suspension method (Quayle, 1969) with polypropylene banding or twine replacing the wire. The twine or banding was looped and placed through the hole in the cultch. A nail or plastic pin was then inserted through the loop to secure the cultch. This technique was much faster and cheaper than threading shells and twisting wire but it did require "punched" shells.

"Punched" shells were the result of a seed collection method which used strings of wire holding about 60 shells which had been holed by a machine or a hammer with a point. The summer of 1978 was the last year in which any quantity of punched cultch was used to collect seed. Following years saw the near universal adoption of "vexar" bags, an expanded mesh tube, which contains the cultch during holding, transporting and seed collecting.

This new spat collection technique, while much cheaper for the collector, had disadvantages for those growers who wished to use the seed in twine or band culture. The shell still had to be punched and often the bags contained quantities of small oyster shell and clam shell which could not be punched.

The initial work of attaching the shell to the twine or banding and the post harvest work of cutting the string between clusters of oysters and separating the oysters were time consuming and costly. The oyster separation problem results from the high spat densities frequently found on naturally seeded cultch. In raft and longline culture, the majority of spat on the shell at the time of hanging survive, provided flotation is sufficient. The end product often consists of large clusters of flat oysters. As can be seen from Fig. 1, these are difficult to handle in the shucking shed, and growers are forced to spend time breaking clusters into more manageable sizes.

Endeavouring to overcome these labour intensive aspects of hanging culture, many growers adopted a rope stringing technique used in northern Japan. The Japanese method relies on the twisted strands of the rope holding the shell in place. The .032 mm (1/8th inch) rope which was developed specifically for oyster culture (first in 4 strands and later in 2) also permits the use of small shell and clam shell (Fig. 2). The rope was stronger than the twine or banding but slower and more difficult to cut at harvest, and thus did not result in a sufficient reduction of labour inputs.

Figure 1. Large cluster of string grown oysters.

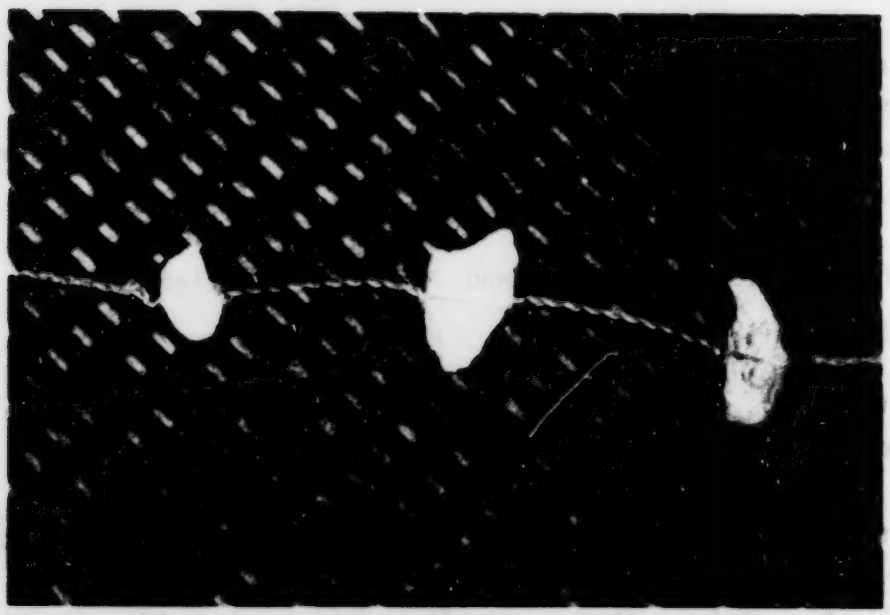

Figure 2. Oyster shell cultch in rope.

CRITERIA FOR THE IDEAL OFF BOTTOM CULTCH

The work of stringing cultch, along with difficulties associated with cluster removal and breakdown, prompted a number of growers to consider an array of new cultch materials that would resolve these problems.

The ideal shape and substance had to retain the best features of shell cultch--its proven spat catching ability and spat retention qualities and, in addition, facilitate conversion of the spat collector into a grow-out device.

A cultch of low weight and bulk would minimize transportation costs as well as befit the limited sized larval setting tanks which are now becoming a reality in British Columbia.

The cost of the cultch itself, within reason, was not considered to be a major factor given the highly sensitive labour expenditures associated with all aspects of existing off bottom methods. Nevertheless, a reusable cultch would certainly attribute to cost reduction.

Another inherent possibility of such a cultch would be the reduction of fouling organisms by suspending the cultch with attached spat at the requisite depth to avoid fouling at each site, but still remain within the optimum growth zone.

The ideal cultch would also lend itself to automated stripping prior to processing.

The following summarizes the important criteria of artificial cultch suitable for off bottom culture:

1. effective oyster spat collector in both natural and hatchery situations;

2. able to retain spat to maturity without excessive sloughing, when suspended either vertically or horizontally;

3. light weight and reasonable bulk;

4. ease of handling during collection, grow-out, harvest, processing and storage;

5. reasonable cost and reusable if possible; and

6. useable in both hanging and near bottom culture.

LITERATURE SURVEY AND CULTCH RESEARCH FROM 1981-83

An extensive literature search was conducted to determine if any existing artificial cultch presently used in the world would fulfill the preceding criteria. Although no immediate transferable technology was evident, a plastic of some form seemed the most promising solution to the artificial cultch problem.

Quayle (op. cit.) commented that sheet polyethylene and polyvinyl chloride (P.V.C.) have been used with varying degrees of success. Experiments in the United States with Crassostrea virginica demonstrated that when no shell is present oysters set on plastic in significant numbers (S. Stiles, pers. comm.). In Japan narrow strips of "vexar" were experimented with as a medium for spat collection and grow-out. The set was satisfactory but no final evaluation of its effect has been made (Bardach, 1972). In France, plastic dishes, ribbed plastic laths and perforated plastic tubes are used with success (Clayton and Saxby, pers. comm.).

In 1981 a wide range of locally obtainable rubber and plastic materials were set out in Pendrell Sound, British Columbia, to determine their spat collecting ability (Appendix 1). The French plastic collectors mentioned above were imported and also set out. These collectors consisted of:

1. Mini hats - small plastic dishes with conical spaces and a ribbed surface.

2. "Cadre de Captage" - a set of slightly ribbed plastic laths, stacked and held together with rubber bands.

3. Tubes[1] - 2 m round hollow tubes 20 mm O.D. with 30 longitudinal grooves 3 mm deep in a V-shape.

[1]Unexpectedly, the grooved plastic tubes were imported from France instead of the perforated ones.

All the test materials and collectors were placed on three floating lines with conventional shell bags being placed at frequent intervals. No particular order was adopted, although an attempt was made to group the artificial cultch in sets comprised of a sample of each. The samples were well distributed to increase the probability of obtaining an acceptable set on at least some, if not all of the samples.

Despite these efforts, a poor commercial set occurred in Pendrell Sound and no conclusive data were acquired.

Fortunately, during the summer of 1981, the Marine Resources Branch set up an oyster spatfall monitoring operation in Pipestem Inlet, British Columbia. The researchers were given short notice of a pending set, but because of time constraints it was impossible to transfer all the cultch samples from Pendrell Sound to Pipestem Inlet. It was decided that only the imported collectors would be set out in the Inlet primarily because of their proven collecting capability in France.

The mini hats were suspended from a floated longline on No. 12 galvanized wire in sets of 50. The "Cadre de Captage" were simply suspended from the longline on rope bridle tethers. The tubes were either assembled in their plastic holders/spacers, or were suspended individually in horizontal and vertical positions on the longline. Tubes were also hung in the intertidal zone in both a horizontal and vertical fashion. Tubes were put in the water first, The mini hats and "Cadre de Captage" were put in the water 24 hours later.

The results of the spat catch on the French collectors are summarized in Table 1. Out of the three collectors, only the tubes placed in the horizontal position (intertidally and subtidally) acquired an acceptable catch. These results are consistent with findings in a study of setting intensities relative to the angle of cultch. Concrete coated lath in a horizontal position caught well in comparison to lath in a vertical position which caught little or no spat (Quayle, 1969).

Table 1. Spat catch on plastic collectors placed in Pipestem Inlet, 1981.

Collector Type	Mean No. of Spat (per m)	Range (Per m)
Tubes - Horizontal		
- Intertidal (beach)	57	30 - 140
- Subtidal (line)	150	100 - 250
Tubes - Vertical		
- Intertidal (beach)	0	0
- Subtidal (line)	0	0
Cadre de Captage		
- Horizontal subtidal	0	0 - 5
Mini Hats		
- Subtidal	0	0

The "Cadre de Captage" contained a very sparse set albeit they were strung in the horizontal fashion. Two possible causes for this have been suggested. Firstly, the tethers attaching the cultch to the longline may have been too long thus placing the cultch outside the zone of optimum spatting. It was interesting to note that a short piece of white 1.27 cm P.V.C. pipe used in the suspension system caught quite well above these collectors. Secondly, the conditioning time may have been insufficient. Conditioning involves pre-exposing the artificial cultch to the marine waters or placing them high in the intertidal zone (3 meters). This tends to neutralize or leach out any toxins issuing from the chemically derived artificial cultch. During the conditioning process the artificial plastic cultch also becomes covered with a thin film of bacteria or fungi--a prerequisite for larval settlement (Seki, pers. comm.).

No spat was collected on the mini hats. Insufficient conditioning time was the probable cause of this failure.

From the preceding experimental work it became evident at this point that, of the artificial cultch tested, the French tubes best suited the criteria previously defined. Thus, all other collectors were abandoned and subsequent experimental work concentrated solely on the tubes.

In 1982, design work was undertaken with Pacific Plastics of Langley, British Columbia, to produce a tube similar to the French type (Fig. 3). Composition analysis revealed that the French tubes are composed of 83% grey scrap P.V.C. and 17% filler. Pacific Plastics was able to produce a white P.V.C. tube in its pure form. The tube has a 20 mm O.D. with 30 sharp longitudinal ridges along the surface. In 1983, the cost was .87¢ per tube in comparison to the French tube which cost .61¢ per tube. Besides the obvious convenience of local supply, this product is stronger than the French tube because of its thicker walls.

In 1983, local tubes were suspended in a horizontal fashion from a floating longline. Natural or wild catches ranging from 80-300 spat per metre ($\bar{x}$ = 135 spat/metre) were obtained providing that the tubes are conditoned for a week.

Further research was conducted in setting tanks at Redonda Sea Farms, Refuge

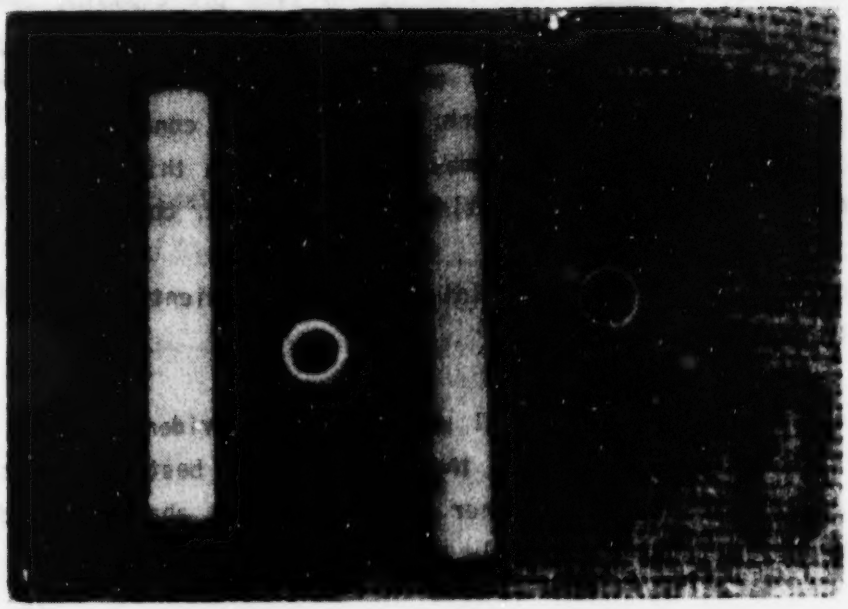

Figure 3. French (right) and local (left) tubes.

Cove, British Columbia. These experiments demonstrated that unconditioned tubes caught nothing, while those conditioned intertidally at the 3 metre level for a week caught between 5-10% of the total eyed larvae introduced into the tank. New tubes conditioned for a year, and high pressure cleaned used tubes conditioned for a week, had a mean catch rate of 25%. Only those tubes placed in the setting tank immediately following the conditioning process caught successfully. It is theorized that excessive air drying of tubes following conditioning destroys the thin films of bacteria or fungi necessary for successful larval settlement. Further trials are necessary to determine if shorter conditioning periods (e.g. over winter) would be sufficient to realize a 25% catch rate with new tubes (Gibbons, pers. com.).

Figure 4. Local tubes in "Vexar" showing set from 1983 Pipestem Inlet spatfall.

SPAT COLLECTION, GROW-OUT AND HARVEST SYSTEMS FOR TUBES

Operators of largescale off-bottom oyster farms in British Columbia are now aware that material handling problems are a severe inhibitor for a profitable business. The possibility of the tubes serving as a collector and grow-out system with a large reduction in labour requirements was the primary attribute for their adoption and future use.

Spat Collection System

A suitable suspension method for natural spat collection is still being developed. The French tubes arrived complete with round plastic disks. Each disk allowed eight tubes to be slotted into holes on the perimeter, with one tube as a middle rod through a centre hole. A disk was placed at each end of a set of nine tubes, and a rubber band was used to hold them in place. This system would be useful for larval setting tanks or if spat collection was taking place intertidally. It was difficult, however, to attach sets of tubes to a longline for subtidal natural spat collection.

Subsequent efforts to solve this suspension problem during seed collection have made use of "Vexar" and notched pipe. A 3/4" "Vexar" was cut into rectangles sufficient to give a 9 x 9 tube bundle (see Fig. 4). Also, lengths of 50 mm O.D. plastic pipe have been drilled with 20 mm holes, ripped lengthways through the centre of the holes, and the resulting pieces of notched half pipe were used as spacers for tubes. Cultch tubes were then laid in the exposed 20 mm notches, with the complete bundle being tied. This system was extensively used in a larval setting tank as well as in Pendrell Sound.

A simple and cheap, although awkward, method of handling tubes for natural seed collection either on beaches or from lines is shown in Fig. 5. One possible benefit from this method is that the set density may be reduced where tubes cross one another. Very dense seed sets have consistently been observed in the centre of tube bundles during natural spat collection (Fig. 6).

Figure 5. Stacked tubes ready for seed collection.

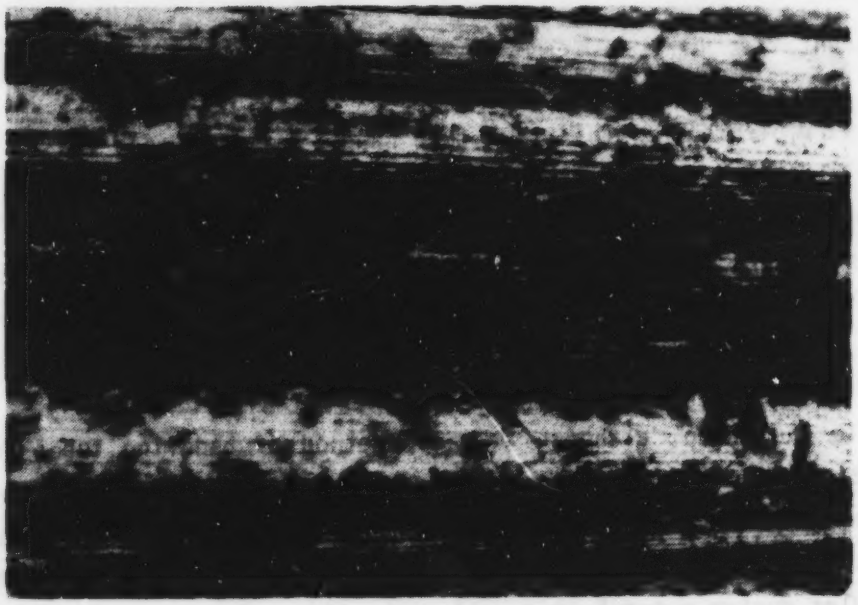

Figure 6. Spatfall on centre tubes compared with spatfall on external tubes from 1983 Pipestem.

Grow-Out

Upon removal from Pipestem, collectors, spatted in 1981 were divided into two groups, one group was held at Redonda Sea Farms, Refuge Cove, and the balance at Esperanza Sea Farms at the head of Lemmens Inlet near Tofino. Some tubes were hung from longlines both vertically and horizontally (Fig. 7 and 8), and some were placed intertidally for a period of hardening.

At Refuge Cove some fall off or sloughing of larger oysters from the tubes was observed. This happened during harvest, especially if the tube was flexed, but was more prone to occur with high density sets (400+ spat per tube). During grow-out trials in sheltered areas this has not been observed to occur naturally. The losses during harvest are of the same order as those from conventional string culture.

A potentially more serious limitation of the tube as a grow out device is the lack of space for growing oysters to "cup up" when the set is dense. A large number of spat per tube, that is 400 or more, is undesirable if the tube is going to be used for hanging culture. Growth and condition index measurement of oysters grown on tubes have indicated that average size and condition index decline as the number of oysters increase beyond approximately 300 per tube (Vieaux, pers. comm.). Redonda Sea Farms have found that tubes with a dense set yield unbroken small oysters for tray or beach culture if the end of the tube is hit sharply with a hammer. The best time to do this is when the seed is between 25 mm and 50 mm (Valiela, pers. comm.). In these situations the thinning method developed at Refuge or the stacked collection system (Fig. 6) hold promise as means to reduce the spat count.

During the grow-out trials, tubes were suspended both horizontally and vertically. The extra work required to place tubes in the horizontal, ladder like formation offered no advantage and it was discontinued. The standard method presently employed is a 2 m tube attached by a leader of light cord, or .125 cm rope, to the longline with clove hitches at both the tube and main line. In the future no doubt faster methods will be developed involving clips of some sort to accelerate both hanging and harvest.

Figure 7. Tubes hung vertically.

Figure 8. Tubes hung horizontally.

Harvest

A Japanese scallop "pick up" device facilitated harvest during trials at Refuge Cove (see Fig. 9). The starred pully (Fig. 10) allowed the boat to move along the main line using the power of a rope tugger. The main line was lifted well clear of the water and greater efficiency was achieved by not having to lower the line, move the boat and rehaul the line after each section of tubes was harvested. The adoption of this system should permit harvesting to take place in the same position on the boat at all times. This will make it easier to develop a means of providing support for the tubes over their full length should this prove necessary when the oysters are fully matured.

Many of the oysters can be easily removed from the tubes by hand or with a flexing motion. It has been suggested that a corn decobber tool could be used during harvest (Washsmuth, 1984). No work has been done to develop methods or requirements for tube cleaning and reuse, although the tubes are reusable and should catch spat better with age.

Figure 9. Vessel using Japanese scallop pick-up device to harvest.

Figure 10. The starred scallop pick-up wheel in action.

COST COMPARISON BETWEEN PLASTIC TUBES AND UNPUNCHED SHELL USED IN OFF BOTTOM CULTURE

The intent of artificial cultch is to reduce the shell stringing and harvest labour costs associated with conventional shell cultch in off bottom systems.

Esperanza Sea Farms Ltd. findings indicate that approximately 15 person hours are required to harvest shell stock sufficient to provide 300 litres of shucked oysters. This work involves pulling up strings, cutting rope between clusters, breaking clusters to separate oysters and sorting replants from shuckables. This time estimate does not include running to and from the lease or the unloading of vessels, etc. It may be possible to improve upon the labour rates given above with lightly set shell cultch because clusters would not need to be broken up.

Tests performed on partly grown oysters on tubes demonstrated that the majority came off easily by hand. Very little shell damage was observed. It appears that the labour required to strip tubes would be less than for shell cultch if hand methods only were used.

An additional potential advantage that the regular shape and size tubes have over irregular shape and size shell cultch, is that they better lend themselves to mechancial separation.

Table 2 is a cost comparison of plastic tubing versus oyster shell cultch. Setting tank seed requirements were determined based on 20% of the initial number of eyed larvae spatting out (1 spat/10 cm^2). A further 50% grow-out mortality was included in calculating the final cost per litre. The cost of the tubes was amortized over a 2 year service life. Labour was based on a rate of $6.00 per hour.

The table has been simplified by parallel detailing of costs directly related to tube and shell cultch seed collection and grow-out techniques. Other expenditures for a vessel, longline, setting tank, lease fees etc. were excluded. Thus the "seed cost per litre" figure arrived at does not equate to the total farm cost for an unshucked gallon of oysters. However, it does reflect the overall efficiency associated with the tube and oyster cultch techniques.

The seeding cost for a litre of oysters is .46¢ and .76¢ per tube and shell cultch, respectively. Clearly, the efficiency of tube culture makes off bottom oyster farming more attractive from an economic standpoint.

Table 2. A comparison of material and labour costs for seeding, hanging, and harvesting of plastic tubes and shell bags when used in off bottom culture.

	2 m PVC tube	"Vexar Bag" (120 oyster shells)
Cultch	.44	1.50
Eyed larvae ($130.00/million)	.16	1.01
Setting & handling costs	.38	.42
Stringing material	.05	4.30
Stringing labour	.05	1.29
Harvest labour	.30	6.00
Total	1.38	14.52
Yield[1]	3 litres/tube	19 litres/vexar bag
Cost per litre for seed and handling	.46/litre	.76/litre

[1] See Appendex III for yield calculation.

SUMMARY OF FINDINGS

1. Ridged P.V.C. tubes proved to be a satisfactory cultch for seed collection and grow-out.

2. Preliminary cost data suggests that considerable savings can be made by using tubes in place of shell cultch in off bottom oyster culture.

3. High density sets on tubes may be a problem which will require a solution. A mechanical solution to this is more possible than with shell cultch because of the regular shape of the tube.

4. New tubes must be conditioned for approximately 1 year and used tubes must be power washed and conditioned for a period of 1 week to realize a 25% catch rate in a setting tank. All tubes must be placed in the setting tank immediately following the conditioning process for the catch to be successful.

5. New tubes used to catch natural spatfall need only to be conditioned for 1 week.

6. Tubes must be placed horizontally to catch spat. Large concentrations of tubes, provided they have space between them, have caught well.

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APPENDIX I - Test Materials and Their Cost

Material	Description	Cost per m
1/16" rubber	cut in 40 mm by 2 m strips placed in bags or wound on to "Nestier" trays	.75¢
1/16" neoprene	as above	.75¢
Polypropylene deck chair webbing	placed in bags	.40¢
"Vexar"	9" mesh, kept flat as possible and wound on "Nestier" trays	.36¢
1-1/2" ABS black pipe	suspended vertically and horizontally	1.90
1/2" polypropylene rope	placed in bags	.15¢
"Netlon" (Italian mussel sacking)	wound on "Nestier" trays	.20¢
Polyethylene square	hung like punched shell	N/C
1/2" PVC pipe (white-series 200)	suspended horizontally	.44¢
PVC moldings (various sizes & shapes)	suspended horizontally	N/C
"Conwed" perf. 47 mm O.D. pipe	suspended	N/C
1/4" polypropylene rope	placed in bag	.03¢
1/2" plastic banding	placed in bags	.01¢
Asbestos cement board	hung	$9.00 per m^2

In addition to these local materials a number of collectors were imported from a French wholesaler (see text).

APPENDIX II - Mean Number of Spat and Range on Test Materials from 1981 Pendrell Sound Oyster Spatfall.

MATERIAL	OBSERVED MEAN # SET	RANGE
Shell (in bag)	1 per shell	0 - 5 per shell
Rubber	3 per m^2	0 - 7 per m^2
Neoprene	none	-
Polypropylene web	none	-
"Vexar"	none	-
ABS Plastic	0.5 per m	0 - 10 per m
Polypropylene rope 1/2"	none	-
Polypropylene rope 1/4"	none	-
"Netlon"	none	-
Polyethylene squares	none	-
PVC pipe	1 per m	0 - 5 per m
PVC mouldings	none	-
"Conwed" pipe	none	-
Plastic banding	none	-
Asbestos board	not placed	-
Mini hats	none	-
"Cadre de Captage"	3 per m	0 - 12 per m
Tubes	5 per m	0 - 10 per m

APPENDIX III Yield (oyster/litre) calculation for PVC tubes and "Vexar Bags"

PVC Tube

Given a 12 cm circumference, 200 cm long
Surface area = 2400 cm^2
Density of spat set = 1 spat/10 cm^2
Therefore 240 spat/tube
Assuming a 50% grow-out mortality this leaves 120 oysters/tube
If 40 marketable oysters = 1 litre
Then 120 oysters/tube = 3 litres/tube

Vexar Bags

Given 120 5 cm x 13 cm oysters per bag
Total surface area of shells - 15,480 cm^2
Density of spat = 1 spat/10 cm^2
Therefore 1,548 spat/bag
Assuming a 50% grow-out mortality this leave 774 oysters/bag
If 40 marketable oysters = 1 litre
Then 774 oysters/bag = 19 litres/bag